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BRAZIL AS AN ECONOMIC SUPERPOWER?
UNDERSTANDING BRAZIL'S CHANGING ROLE
IN THE GLOBAL ECONOMY

TECHNOLOGY, PUBLIC POLICY, AND THE EMERGENCE OF BRAZILIAN MULTINATIONALS

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ABSTRACT

This paper examines the emergence of Brazilian multinationals, focusing on the roles that technology and public policy have played. The paper begins by theoretically contextualizing the discussion, pointing to the prominent role that technology may play in the internationalization of firms. Next, some brief quantitative evidence relating to the growth of Brazilian multinationals and outward foreign direct investment is provided. The discussion then focuses more explicitly on the technology issue, first analyzing the evolution of public policy as it has affected enterprises' decisions to innovate. In the subsequent section, case study evidence is provided concerning the experiences of Embraer, Petrobrás, CVRD (Vale), and Odebrecht and—more briefly—WEG, Marcopolo, and Gerdau. In the course of the case studies, enterprise technological strategies are discussed and their relationship with public policy and internationalization is analyzed. In all cases, it is established that the development of—or the desire to acquire—technology has been a critical factor underpinning the growth of Brazilian multinationals.

I. INTRODUCTION

The explosive growth in outward foreign direct investment (FDI) from emerging market countries is a salient feature of the changing global economic landscape. These emerging market countries—long accustomed to being mere recipients of FDI from Europe, North America, and Japan—now increasingly form the home bases for genuinely global enterprises. Brazil has certainly proved no exception to this trend. Across six continents, Brazilian corporations are entering takeover contests, establishing greenfield operations, breaking into new export markets, or bidding for resources extraction concessions. The names Embraer, Petrobrás, and Odebrecht are fast becoming as globally recognized in their sectors as Boeing, Shell, and Bechtel. Yet while the profile of Brazilian multinationals has never been higher, comparatively little attention[1] has been paid to the factors driving their emergence as truly global players. It is the purpose of this paper to contribute to the sum of understanding here. In analyzing the development of Brazilian multinationals, the paper pays special attention to the critical issue of technological capability accumulation and its interplay with public policy. The focus on technology is not arbitrary or accidental. Instead, it reflects the centrality of technology as a driver of internationalization, at least according to the mainstream theoretical literature.

The structure of the paper is as follows. Section I reviews the theoretical literature concerning enterprise internationalization and the role of technology. Section II then presents aggregate summary evidence concerning recent Brazilian outward FDI trends and the technological characteristics of internationalizing firms. Next, section III discusses the public policy environment and the potential channels through which this may have influenced firms both in terms of internationalization and technological strategy. To analyze these processes at the firm level, section IV then presents case study evidence relating to the experiences of Embraer, Petrobrás, and Odebrecht and—more briefly—Marcopolo, CVRD (Vale), and Gerdau. Finally, by way of a conclusion, the key factors driving the

[1] In English, very little has been published beyond material appearing in UNCTAD's annual *World Investment Report* and ECLAC's annual *Foreign Investment in Latin America and the Caribbean.* As might be expected, more has appeared in Portuguese (the key contributions have been cited in this paper). Still, surprisingly little of this material has appeared in the form of published journal articles or books.

internationalization of Brazilian enterprises are summarized and the relevance of technology, in particular, is considered.

II. TECHNOLOGY AND THE EMERGENCE OF MULTINATIONALS: SOME THEORETICAL PERSPECTIVES

Over the past forty years or so, a rich theoretical literature has developed concerning the ways in which enterprises expand operations beyond their country of origin. This process—which the literature refers to as internationalization—may involve a series of sequential stages, starting with the export of products, moving onwards towards the establishment of representative offices abroad and then to the setting up of full-fledged subsidiaries (or, possibly, joint ventures), and, finally, to the global integration of all operations.[2] Johnson and Vahlue (1977) argued that the accomplishment of each stage of internationalization is necessary in order to gain the information and market knowledge to move on to the next. This suggests that the development of multinational corporations is likely to be a relatively long drawn-out process, involving the transcending of informational barriers through learning and experience.

In seeking to engage in deeper forms of internationalization (i.e., FDI through the creation of foreign subsidiaries or joint ventures), the enterprise is likely to be motivated by a number of factors, some but not all of which will be related to the theme of technology. According to one of the first and most influential theories—the product life cycle theory propounded by Vernon[3]—any given product undergoes five "life stages," starting with research and development, then moving on to initial market penetration, market growth, and then market saturation and decline. As the product enters the saturation and decline phases, the technology it embodies is increasingly commoditized, meaning that the degree of competition intensifies in its core markets. Transferring production to a peripheral, low-cost market not only allows the intensifying competition to be countered in cost terms; it also

[2] For an example of such a sequence, see Ohmae (1987).
[3] See Vernon (1971).

enhances access to less mature markets. In such markets, demand for the product in question is more likely to be expanding than entering a phase of saturation or decline. Thus, in Vernon's terms, FDI and the emergence of multinationals can best be understood as a process of spinning out the life of products whose technologies have fallen behind the international frontier.

Building on the work of Hymer (1968), Dunning (1993) has elaborated possibly the most comprehensive and influential theory of internationalization—the so-called eclectic paradigm. This paradigm holds that a firm will be in a position to internationalize if it is in possession of some firm-specific advantage. Such an advantage may well center on a proprietary technology (for example, ownership of a patent) but might equally relate to a distinctive brand or an effective organizational model. Presuming that a firm is in possession of such advantages (sometimes referred to in the literature as "core competences"), it will have a direct financial interest in exploiting them outside its home market if it believes that its competencies will enable it to gain profitable market share in this domain.

The key question faced at this point is whether the competencies in question could best be exploited through exports, through FDI, or simply through the licensing of the advantage (e.g., through technology transfer or franchising) to third parties. The answer here depends on a number of factors, including the quality and availability of potential licensees/franchisees, the technical feasibility/commercial desirability of wholesale technology licensing, and so on. Presuming that a decision is made to engage in FDI, the question then arises as to where the investment is likely to take place. The eclectic paradigm suggests that decisions here will be guided by three key factors: the availability of healthy markets (the market-seeking motive); the presence of resources, whether in the form of raw materials, ideas, or skills (the resource-seeking motive); or an environment which permits economies of scope or scale and low unit costs of production (the efficiency-seeking motive).

As can be seen, the eclectic paradigm suggests that the development of some technological competence can, in conjunction with some location-specific factors, prove a trigger for internationalization via FDI and thus the emergence of a multinational corporation. Such a

developmental trajectory for a multinational corporation would typically be associated with an *asset-exploiting* strategy. However, it can also be true that firms lacking an obvious technological edge might still seek to internationalize.[4] The motive here springs less from the desire to leverage core competencies than to actually obtain them in the first place. The implementation of such *asset-augmenting* FDI has become increasingly significant in recent years.[5] Thus, for example, an emerging-market-based multinational could establish a subsidiary in an OECD economy with the objective of gaining access to frontier technologies or seeking exposure to cutting-edge management techniques. Such developments have recently become commonplace, especially in the information and computer technology sector.

Although the discussion so far has suggested that technology can be a prime motive force in the drive towards internationalization, it needs to be recognized that other factors are likely to play a critical role. For example, the eclectic paradigm explicitly allows for the seeking of natural resources to be a prime driving force. By the same token, the theory easily accommodates the phenomenon of brand recognition (as opposed to organizational or technological superiority) as a key explanatory factor. The extent to which the emergence of Brazilian multinationals can be viewed as a response to technological forces forms the key question addressed by this paper. Before engaging with it, however, it is worth setting matters in broader context by examining recent trends in the growth of Brazilian outward FDI and the concomitant expansion of Brazilian multinationals.

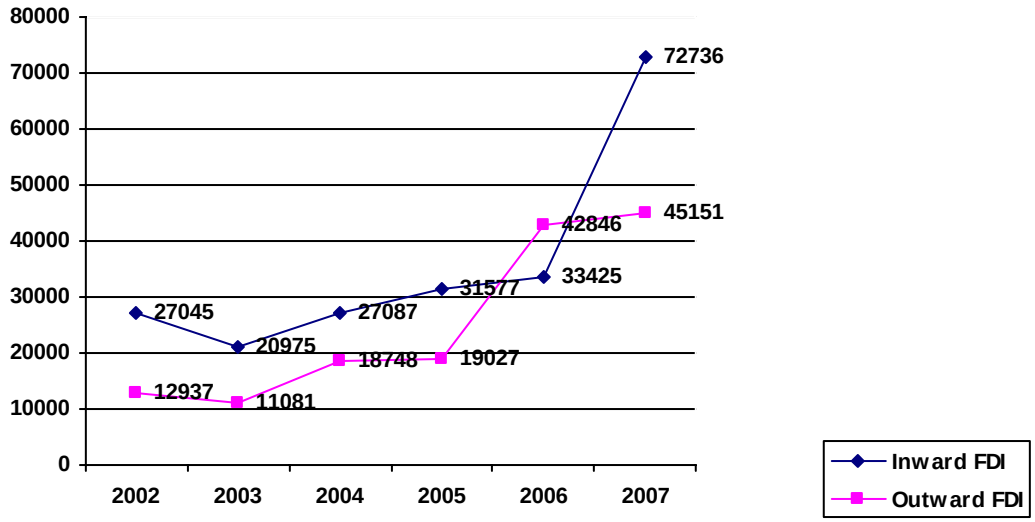
III. THE EMERGENCE OF BRAZILIAN MULTINATIONAL ENTERPRISES: A BRIEF QUANTITATIVE OVERVIEW

One of the most striking developments surrounding the development of the Brazilian economy in the current decade has been the surge in growth in outward FDI. As Chart 1 indicates, between 2002 and 2007 outward FDI flows rose from US$12,937 million to

[4] Provided, of course, that they possess some minimum level of competitive advantage.
[5] See UNCTAD (2006, 142).

US$45,151 million, with outward FDI exceeding inward FDI for the first time ever in 2006.[6] The growth in FDI is being driven by the activities of Brazilian multinationals across an array of sectors, ranging from manufacturing to construction to mining. According to data provided by UNCTAD, the stock of FDI maintained by Brazilian multinationals is the fourth highest among developing or emerging market countries; only China, Singapore, and Taiwan possess (through their enterprises) a greater stock of overseas assets.[7]

Chart 1: Inward and outward FDI flows: Brazil, 2002-7 (US$M)



Source: Banco Central do Brasil.

What is perhaps more dramatic than the sheer expansion in outward FDI flows and stocks is the growth in the number of enterprises generating such investments. Table 1 indicates the impressive rate of growth in the number of parent companies based in Brazil. Although the increase in numbers is far below that achieved in India and China (two of the other BRICS—Brazil, Russia, India, and China—the four very large rapidly emerging economies), it is still very substantial in relation to the developed countries.

[6] FDC / Columbia University Program on International Investment (2007, 5).
[7] See Fiocca 2006 for more details.

Table 1. Number of parent companies, selected developing countries, selected years

	Early 1990s	(year)	Early 2000s	(year)	Rate of Increase (per cent)
Brazil	566	(1992)	1,225	(2005)	116
China	379	(1993)	3,429	(2005)	805
Hong Kong SAR	500	(1991)	948	(2002)	90
India	187	(1991)	1,700	(2003)	809
South Korea	1,049	(1991)	7,460	(2005)	611
Total	2,681		14,762		451
Developed Countries	34,280		50,520		47

Source: UNCTAD (2006, 122).

Despite the increasingly important role of Brazilian outward FDI suggested in the FDI data, it remains the case that few Brazilian multinationals in their respective sectors rank among the very largest worldwide. Ranking enterprises by revenue in 2005 (or the latest available year), UNCTAD's 2006 *World Investment Report* listed only three Brazilian enterprises (CVRD, Petrobrás, and Gerdau) as among the 20 largest in their respective sectors.[8] Perhaps more surprisingly, ranking the 50 largest nonfinancial multinational corporations from developing countries, the 2005 *World Investment Report*[9] listed only three Brazilian enterprises: Petrobrás, CVRD, and Gerdau.[10] Of the top 50, no fewer than 15 multinationals were based in mainland China or Hong Kong, while most of the rest originated in East Asia and Southeast Asia, mainly South Korea, Taiwan, or Singapore. Another interesting feature to emerge from these international rankings concerns the sectoral specialization of the largest Brazilian multinationals. While the largest multinationals from East Asia and Southeast Asia tend to be focused on manufacturing (especially electronics) and services, their Brazilian counterparts are strongly connected to natural-resource-based (NRB) activities, specifically oil and gas, and mining and steel.

[8] See UNCTAD (2006, 123). CVRD ranked as the 5th largest in the mining sector, Petrobrás the 15th largest in petroleum refining, and Gerdau as the 13th largest in steel. No Brazilian enterprise ranked among the 20 largest multinationals in automobiles, chemicals, electronics, banking, construction, container shipping, or telecommunications.

[9] UNCTAD (2005, 65).

[10] Ranking, respectively, 8th, 23rd, and 31st.

Table 2. FDC-CPII ranking of the top 20 Brazilian multinationals, key variables, 2006

Ranking								
Foreign assets	Trans-nationality index	Name	Sector	Foreign assets/total assets (%)	Foreign sales/total sales (%)	Foreign employment/ total employment (%)	Trans-nationality index (%)	No. of host countries
1	2	CVRD	Mining	46	18	24	29	10
2	18	Petrobrás	Oil &gas	12	12	11	12	9
3	1	Gerdau	Steel	39	54	46	46	11
4	6	Embraer	Aviation	45	12	13	23	5
5	24	Grupo Votorantim	Diversified	5	9	4	6	12
6	13	CSN	Steel	18	28	3	16	2
7	9	Camargo Corrêa	Diversified	26	13	18	19	12
8	5	Grupo Odebrecht	Construction& petrochemicals	15	20	47	27	12
9	23	Aracruz	Pulp & paper	19	n.a.	1	7	5
10	7	WEG	Electromechanical	24	30	11	22	12
11	4	Marcopolo	Bus manufacture	30	30	22	27	7
12	11	Andrade Guiterrez	Diversified	4	7	41	17	8
13	8	Tigre	Construction	27	17	17	20	7
14	31	Usiminas	Steel	1	n.a.	n.a.	0.3	0
15	17	Natura	Cosmetics	22	3	15	14	7
16	15	Itautec	IT	19	20	6	15	8
17	19	America Latina Logistica SA	Logistics	2	11	23	12	1
18	26	Ultrapar/ Grupo Ultra	Diversified	2	2	3	2	2
19	3	Sabó	Autoparts	16	43	27	29	11
20	22	Lupatech	Electromechnical	10	4	7	7	2

Source: FDC-CPII survey of Brazilian multinationals; see FDC / Columbia University Program on International Investment (2007).

Moving away from international comparisons and focusing instead on national rankings, the NRB-concentrated sectoral picture begins to fade. Table 2 indicates the results from a recent (2007) survey undertaken by the Fundação Dom Cabral and the Columbia University Program on International Investment.[11] The survey ranked enterprises in order of the value of their overseas assets. Interestingly, the table reveals that this bears only an imprecise relationship with the degree of internationalization (a composite average of foreign assets to total assets, foreign sales to total sales, and foreign employment to total employment). As can be observed, while the NRB-oriented CVRD, Petrobrás, and Gerdau occupy the top 3 slots (out of 20), the remaining positions are filled by enterprises from such diverse sectors as aerospace, construction, information technology, and logistics.

[11] The FDC-CPII survey; see FDC / Columbia University Program on International Investment (2007).

Since data on the international ranking of Brazilian multinationals indicate that the largest are heavily NRB oriented, should this lead one to suppose that strategies of natural resource seeking predominate over those of technology exploitation or acquisition? At least so far as detailed survey data indicate, the answer here is no. Protchnik et. al. (2006) analyzed a large sample[12] of firms using data provided by the Brazilian Geographical and Statistical Institute (IBGE) and supplemented by information from the Central Bank and External Trade Secretariat. The authors attempted to establish whether there was a link between the internationalization of Brazilian enterprises and their decision to engage in different types of product and process innovation. In the case of enterprises which neither exported nor engaged in outward FDI, 69% were found not to have undertaken any form of innovative activity. By contrast, over 80% of firms which exported or invested overseas had engaged in product innovation. In the case of process innovation, just 24.7% of firms had failed to internationalize, either through exporting or outward FDI.[13] The study also establishes that the Brazilian enterprises which invest overseas tend to be the most aggressive in terms of pursuing innovation closest to the frontier.

The fact that a positive association exists between innovation and internationalization and the fact that NRB-oriented enterprises are so prominent among Brazilian multinationals are not in any way contradictory. As section IV reveals, operating in the natural resources sector—especially at a time when new mineral and oil deposits are ever less accessible—is an increasingly technologically intensive activity. Fortunately for Brazil, its leading NRB-focused multinationals have been highly successful in developing and absorbing cutting-edge technologies. At the same time, it needs to be borne in mind that Brazilian multinationals operate increasingly effectively in other sectors, notably manufacturing. Section IV reveals evidence of the close relationship between internationalization and innovation here. Before discussing this firm-level evidence, however, it is worth briefly detailing the domestic policy environment within which firms make decisions to invest in technology and to extend their activities abroad.

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[12] IBGE's PINTEC database, the central reference source used for the study, contained 9,687 enterprises.
[13] See Prochnik et al. (2006, 361).

IV. THE PUBLIC POLICY ENVIRONMENT AND THE INTERNATIONALIZATION OF BRAZILIAN ENTERPRISES

The role of public policy is becoming increasingly recognized as a critical influence in the emergence of multinational corporations from less developed economies.[14] Through both microeconomic and macroeconomic policy interventions, the state can exercise strong influence on the growth of domestic enterprises, on their investment decisions, and on their technological strategies. In the Brazilian context, in particular, it would be difficult to overestimate the role of the state in the formation of homegrown multinationals. Starting in the 1930s but accelerating into the 1940s, 1950s, and 1960s, Brazil underwent a program of state-directed, inward-oriented industrialization—an economic program which has become known as import substitution industrialization (ISI).[15]

The pursuit of ISI led to a structural transformation, resulting in a full-fledged industrialized economy. In its wake, ISI created expanding market opportunities for domestic as well as foreign enterprises and saw the formation of the large domestic economic groups that feature so prominently among the Brazilian multinationals of today. Another notable feature of ISI was the establishment of state-owned enterprises (SOEs), especially in capital-intensive sectors such as steel making, energy, telecommunications, and mining.[16] It is worth noting that two of Brazil's top three multinationals—CVRD and Petrobrás—were established as SOEs, with Petrobrás continuing to be controlled by the state.[17] Former SOEs are also prominently represented in the FDC-CPII list of Brazil's top twenty multinationals.[18] Privatization and the abandonment of ISI in the early 1990s have significantly reduced the

[14] See Guedes and Faria (2005) for a wide-ranging discussion of the conceptual issues.
[15] See Kohli (2006) for a detailed discussion. ISI involved the erection of tariff and nontariff barriers to foster domestic industrialization. Initially, ISI in Brazil focused on the establishment of a consumer durables sector. By the late 1970s, the strategy had broadened to include the launch of a capital goods sector.
[16] See Baer (2008).
[17] CVRD was privatized in the 1990s, while Petrobrás continues to be controlled by the state, albeit with substantial private shareholding.
[18] Aside from CVRD and Petrobrás, Embraer, CSN, and Usiminas were, at one time, SOEs; see FDC / Columbia University Program on International Investment (2007).

state's direct role in the economy. Nevertheless, public policy remains a highly significant factor in explaining the growth and internationalization of Brazilian enterprises.

In discussing the contemporary role of the state, it should be acknowledged at the outset that the Brazilian government maintains in place no policy set explicitly designed to encourage domestic enterprises to invest overseas. Instead, it is possible to argue that particular interventions *implicitly* assist Brazilian enterprises in their attempts to expand operations internationally. A critically important channel here is formed by export finance initiatives. Fiocca (2006) points to the vitally important role of Brazil's National Economic and Social Development Bank (the Banco Nacional de Desenvolvimento Econômico e Social, BNDES) in supporting internationalization via the financing of Brazilian exports. Between 1996 and 2005, the BNDES's export finance disbursements rose from US$890 million to US$5.86 billion, with particularly strong growth experienced in relation to financing overseas capital goods sales.[19] The BNDES is also becoming very active in financing export sales related to overseas infrastructure projects in which Brazilian construction firms are involved.[20] As seen in section I, the intensification of exports represents a vital prior step which enterprises have to take in order to gain exposure to local market conditions. In this sense, the increased focus on export promotion is creating a favorable environment for increased outward FDI.

In pointing to the implicit role of state policies in encouraging outward FDI and the growth of Brazilian multinationals, it is also important to refer to the effects of macroeconomic policy. Since the implementation of the Real stabilization plan in 1993–94, the pursuit of orthodox fiscal and monetary policies has driven annual inflation from quadruple to single digits.[21] This has allowed benchmark interest rates to drift downwards over time. At the same time, reforms have improved liquidity and financing conditions in Brazilian equity

[19] Fiocca (2006, 20).
[20] Ibid., 23. Camargo Corrêa, Grupo Odebrecht, and Andrade Gutierrez (which feature in Table 2) are heavily involved in overseas construction and would benefit from such financing programs.
[21] See Amann (2005).

markets.[22] Taken together, these developments have improved access to domestic capital markets, in turn enhancing Brazilian multinationals' ability to finance research and development (R&D) projects or FDI. The successful conduct of Brazilian macroeconomic policy has also lent support to the Real, whose value has substantially appreciated against the U.S. dollar and other major currencies since 2002. Such a development is clearly of value to enterprises seeking to pursue foreign acquisitions, to inject capital into existing overseas operations, or to initiate greenfield investments.

Important though these policy features are, the key focus in this paper concerns the role that firms' technological strategies may be playing in their decision to initiate or expand operations overseas. In this connection, what role has the Brazilian state played in facilitating innovation among enterprises? This is a substantial and complex question, and limitations of space here do not allow for a detailed treatment.[23] In what follows, an overview of the some of the more salient features of Brazil's technology policy regime is provided. Some additional discussion relating to this theme will also be offered on a firm-by-firm basis in section IV.

Since the 1960s, the Brazilian government has pursued a series of policy initiatives designed to build technological capabilities in both the public and private sectors. The objective here has been to create new comparative advantages in higher-value-added activities, thus diversifying the economic base and improving the terms of trade. In attempting to achieve these goals, successive governments have relied on a variety of initiatives and, in the process, have created a comparatively elaborate policy architecture. Among the key features of this policy framework is a special funding body, FINEP, whose function is to distribute financing and grants to public and private sector organizations pursuing research projects. So far as direct public financing of corporate research is concerned, FINEP is by far and away the most important funding body. The activities of FINEP are supplemented by the work of FINAME, which, in association with the BNDES, provides financing packages to support the sale of technologically complex capital goods. Another important element of the policy

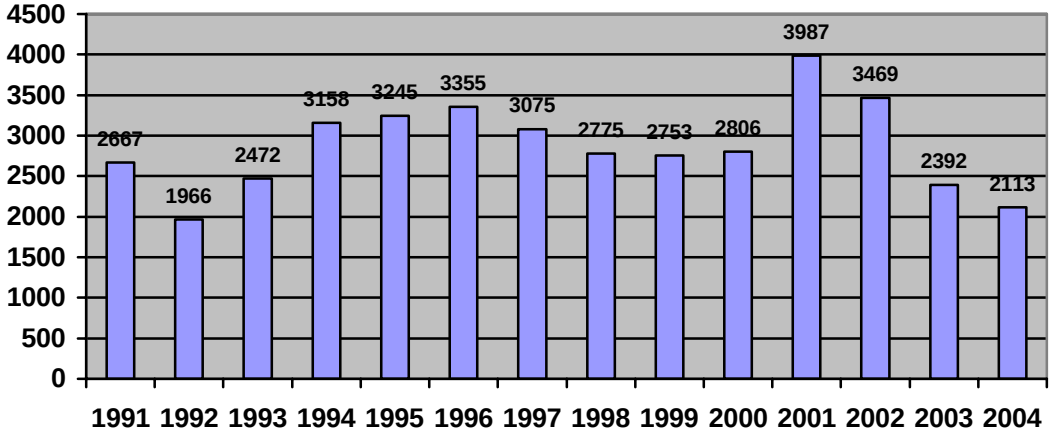
[22] In March 2008, Brazil moved to the top of the emerging market index, a measure based on strong growth in its equity market (*Economist*, March 8, 2008). Still, it needs to be recognized that, despite reduced benchmark interest rates, interest rate spreads remain high by advanced economy standards.

[23] Those seeking a more detailed treatment of these issues—at least in terms of policy design—would do well to consult Mani (2002).

architecture is formed by universities and publicly funded research institutes, many of which operate in collaboration with enterprises on research projects. Among the most famous examples here would be the IPT (Instituto de Pesquisas Tecnológicas, Institute of Technological Research) at the University of São Paulo and the EMBRAPA agricultural technology research institutes. The former has been associated with innovation in the engineering sector while the latter have been closely involved in developing new crop strains.

Another extremely important source of support for corporate R&D over the years have been the in-house research institutes originally founded by the SOEs. Thus, for example, in the case of telecommunications, the former SOE Telebrás established the CPQd Institute, which was responsible for the development of Brazil's first digital telephone exchange. In the case of electricity, the SOE holding company Eletrobrás founded the Cepel research institute, which has made a number of advances in high-tension power distribution. Despite the privatization of the telecommunications sector and large parts of the electricity sector, these research institutes remain operational with special lines of funding. In the case of Petrobrás, the CENPES research institute has played an important part in developing world-class technologies in offshore oil exploration and production (see the next section).

Chart 2: Government spending on science and technology in Brazil, 1991-2004 (constant R$ millions)



Source: Ministério de Ciência e Tecnologia (MCT).

While the institutional architecture supporting corporate research and development in Brazil may appear well developed, this does not imply that the recent evolution of public funding has been particularly favorable. As Chart 2 indicates, in real terms, despite upward fluctuations from time to time, government spending on science and technology[24] was lower in 2004 than it had been in 1991.

Table 3. Spending on Science & Technology in Brazil, 2000–4 (%GDP)

	2000	**2004**
Public spending	1.30	1.28
Federal government	0.79	0.71
State governments	0.53	0.49
Business spending	0.16	0.22

Source: MCT.

Comparing 2000 with 2004, Table 3 further indicates the troubling extent to which public expenditures on science and technology have come under pressure. The table clearly shows that public spending has fallen as a proportion of GDP, a development which does not appear to be compatible with the strategic desire to boost competitiveness and develop new comparative advantages in technologically dynamic sectors. The configuration of fiscal policy may help explain this adverse trend. Constrained by the need to generate large primary surpluses and squeezed between high debt repayments and expenditures on nondiscretionary items such as pension and social security payments, public sector investment has remained subdued.[25] Against this background, it has been difficult for the Ministry of Science and Technology and other relevant federal agencies to increase their spending year on year in real terms. The compression of public spending on science and technology need not have been so serious in its implications if the private sector had significantly ramped up its expenditures. However, in this regard, the table also illustrates another interesting—and disturbing—feature: the subordinate role of business spending on science and technology vis-à-vis that of the public sector. Despite the fact that business spending climbed by 0.06 percentage points of GDP between the two years, it still remains well below that generated

[24] Such spending, of course, encompasses not only assistance to corporate R&D but also public investment in basic science within the university system.
[25] See Amann and Baer (2006) for a comprehensive analysis.

by the public sector. Thus, at least reviewing the aggregate data, there is cause for concern surrounding not only the incidence of public sector spending on science and technology but also the tiny proportion generated by business.

Table 4. R&D Spending: International Comparisons

Country	Year	R&D Spend (US$M PPP)	R&D Spend (%GDP)	R&D Spend (US$ per capita)
Brazil	2004	13,494	0.91	74.3
Argentina	2003	1,826	0.41	49.6
Mexico	2001	3,624	0.39	36.2
China	2003	84,618	1.31	65.6
S. Korea	2003	24,379	2.64	508.7
Russia	2003	16,926	1.29	118.0
France	2003	37,514	2.19	609.6
Germany	2003	57,065	2.55	691.5
U.K.	2003	33,579	1.89	563.8
United States	2003	284,584	2.60	977.7

Sources: OECD/MCT.

Two key factors may help to account for the generally limited role of the private sector as an investor in science and technology. In the first place, and unlike the Brazilian multinationals reviewed subsequently, it is far from always the case that survival (at least in the domestic market) depends on the ability to develop or acquire cutting-edge technologies.[26] Second, even where such innovative activity is more strategically necessary, enterprises' ability to divert resources into R&D ventures is often constrained by a lack of access to capital and a risk aversion borne of years of coping with significant macroeconomic instability.[27] Fortunately, this situation looks likely to change in the future owing to the increasing depth, sophistication, and liquidity of Brazilian equity markets.

The sense that overall spending on innovation in Brazil is "low" is accentuated when one makes international comparisons. Although compared to its Latin American peers,

[26] Amann (2000).
[27] Ibid.

Argentina and Mexico, Brazil's proportionate spending on R&D[28] is impressive, with regard to Europe or the United States, it lags far behind (see Table 4). The lag is particularly noticeable in relation to South Korea, a newly industrialized economy to which Brazil is often compared.[29] While these data present a picture of technological underinvestment, they are nonetheless only average indicators. What the data conceal is the fact that—despite currently constrained public funding—some Brazilian corporations have succeeded in developing world-class technologies and have used these as a springboard to internationalization. The nature of this phenomenon and its broader implications form the basis for the next section and the conclusions.

V. TECHNOLOGY AND THE INTERNATIONALIZATION OF BRAZILIAN ENTERPRISES: SOME CASE STUDIES

EMBRAER

The Brazilian aircraft producer Embraer is one of Latin America's highest-profile enterprises, operating in a sector where the technological frontier has been moving rapidly. Not only has Embraer succeeded in maintaining its products and processes at the leading edge of the frontier, it has parlayed this achievement into market success. In so doing it has become one of the world's two leading producers of regional jet passenger aircraft.[30] Having demonstrated its technological virtuosity and commercial viability, Embraer has embarked on a more profound phase of internationalization, launching operations in Portugal and China. As a consequence of this development, Embraer has become a full-fledged multinational corporation. The progressive internationalization of Embraer cannot be understood without reference to its technological strategy. At the same time, this technological strategy cannot be understood without reference to the role of the state.

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[28] R&D is a narrower measure of innovative activity than spending on science and technology. It excludes spending on basic science and relates to the development of technologies by both private sector corporations and public sector universities and research institutes.

[29] See Amann and Chang (2004) for a lengthy discussion of these comparisons.

[30] The other being Canada's Bombardier.

Although Embraer was founded in 1969, its origins can be traced back to the 1940s, with the creation of the Aeronautics Technology Center (CTA) by the Ministry of Aeronautics.[31] The CTA was charged with undertaking research on basic aerospace technologies, including aircraft design, engines, and materials. Soon after its founding, the CTA established a Technological Institute (the ITA), whose objective was to train specialized engineers.[32] In the mid-1950s, a further CTA-linked institute—the IPD (Institute for Research and Development)—was set up. Throughout the 1950s and 1960s, these state-directed technological initiatives enabled the accumulation of basic capabilities. These would later prove invaluable in the establishment of a viable national aircraft industry. The launch of Embraer at the end of the 1960s represented an attempt to capitalize on these capabilities at a time when Brazil was trying to improve its balance of trade position. It was hoped that Embraer would supply the domestic market, lessening the demand for imports,[33] while at the same time driving up exports. In fact, there was a strong emphasis on exports from the start, the advantage here being that a focus on external markets would bring longer production runs, greater scope for technical change, and exposure to tough quality and performance standards.[34] Embraer initially targeted the market for smaller propeller-powered civilian aircraft and military trainers. During this period—the early 1970s—some technology was acquired through a manufacturing cooperation agreement with Piper aircraft of the United States.[35] This allowed the production of very light aircraft for personal transportation and agricultural use. More ambitious—and successful in sales terms—was the larger 19-seat Bandeirantes launched in 1973.

During the 1970s and 1980s, Embraer remained an SOE, enjoying a special relationship with the Ministry of Aeronautics and the Brazilian Air Force. The period saw more ambitious attempts to master technologies relating to jet aircraft design and production. Thus, in 1980, Embraer embarked upon a program to develop a jet fighter (the AMX), drawing on in-house designers, researchers at the CTA, and technical cooperation from two Italian enterprises,

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[31] Silva (1999).
[32] Cassiolato et al. (2002, 7).
[33] In this sense, the launch of Embraer could be seen as part of the ISI strategy (Goldstein and Godinho 2007, 4).
[34] Ibid., 5.
[35] Cassiolato et al. (2002, 8).

Aeritalia and Macchi Aeronautic. By the end of the 1980s, after two decades of operations, Embraer had carved out a notable niche in the international aerospace market as a designer and manufacturer of regional propeller transports.[36] The enterprise had also grasped the rudiments of jet aircraft design through its experience with the AMX. The acquisition of these capabilities proved a springboard to yet more success as Embraer moved into the emerging market for regional passenger jet transport.

In 1989 Embraer embarked upon the design and development of the ERJ-145, a twin-engine, 50-seat passenger jet designed for use on regional routes. Once again, the project was able to draw on locally acquired expertise centered on the CTA and Embraer itself. The design and development of the ERJ-145 also relied on extensive cooperation and risk-sharing agreements with major suppliers. Thus, for example, while Embraer would perform the overall design function and integrate the various systems, Gamesa of Spain was responsible for wing development and manufacture and Sonaca of Belgium was awarded a contract to develop and manufacture the center fuselage section.[37] Other suppliers in Europe and North America were responsible for the avionics and the engines, for which Embraer (or other Brazilian enterprises) did not possess the technology. The ERJ-145 program firmly established Embraer as a world-class systems integrator and assembler. This experience was to be put to use in the later development of the larger ERJ-170/190 jet. What both programs did not involve, however, was a concerted attempt to add more value added locally. This was despite the existence of local supplier clusters[38] and, in the late 1990s, increasingly acute trade deficits.

A critical juncture in Embraer's history came in 1994 with privatization.[39] Struggling with losses, its very survival appeared in question. However, the launch of the ERJ-145 at the 1996 Farnborough Airshow and subsequent huge orders from American carriers ensured that, rather than fail, Embraer would go on to spectacularly prosper. Since the mid-1990s,

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[36] The most successful products of this type being the EMB-110 Bandeirante for 19 passengers and the EMB-120 Brasilia for 30 passengers.
[37] Ibid., 31.
[38] See Bettencourt et al. (2005) for a detailed discussion on themes relating to the domestic Brazilian production chain for civil aviation.
[39] Foreign ownership was limited to 40%. Among the foreign investors came to be a consortium of EADS, Dassault, Thales, and Snecma, with an acquired total of 20% of the voting shares (ECLAC 2005, 73).

more than 800 ERJ aircraft have been sold, making—for awhile—Embraer Brazil's biggest exporter. According to Goldstein and Godinho (2007, 6) more than 95% of Embraer's sales are made abroad. While Embraer may have been privatized, the Brazilian state has nonetheless continued to offer it strong support. Research collaboration persists with the CTA and its satellite institutes while Embraer is collaborating with state and federal agencies on the creation of enhanced local R&D capabilities.[40] The lingering role of the state has been especially pronounced in relation to exports, where the BNDES has offered special export-financing facilities. The perceived overgenerosity of these triggered a complaint by Canada (where Bombardier is based) at the World Trade Organization (WTO).[41]

According to the theoretical material reviewed above, export success may represent a crucial first step towards deeper internationalization. This, of course, would take the form of outward FDI. It is significant that Embraer's establishment of overseas operations has accompanied its increasing success in penetrating export markets. Initially, foreign investment took the form of the establishment of foreign maintenance facilities.[42] Such investments were a natural concomitant of exporting a complex and maintenance-intensive product. However, in 2002 Embraer announced plans to construct an ERJ-145 assembly line in China.[43] The creation of this first overseas production facility for Embraer was primarily motivated by a desire to gain enhanced access to the Chinese market.[44] In particular, it was thought that by commencing production inside China, Embraer would gain a significant market access advantag over its archrival Bombardier. In December 2003, the first Chinese-assembled ERJ-145 made its maiden flight, triggering a series of orders which have proved

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[40] Cassiolato et al. (2002, 46).

[41] The dispute erupted in 1996 and centered initially on the Canadian allegation that Brazil's PROEX export finance package breached WTO rules by financing too great a proportion of the value of Embraer's sales over too long a period. In 2001, a WTO ruling obliged Brazil to limit the proportion of export sales value financed to 85% over a maximum term of 10 years. Brazil, meanwhile, had alleged that Canadian government support for Bombardier also breached WTO rules. In March 2003, the WTO found in favor of Brazil, allowing the latter to impose US$248 million in trade sanctions against Canada. (*ICTSD Bridges Weekly Trade News Digest*, July 31, 2001; Cynthia Churchwell, *Harvard Business School Working Knowledge*, November 13, 2003). At the time of writing, no further Brazil-Canada disputes had erupted.

[42] ECLAC (2005, 73).

[43] This was achieved through the establishment of a joint venture (in which Embraer owns 51%) with the two SOEs, HAIG and its subsidiary, Hafei Aviation Industry Company.

[44] Goldstein and Godinho (2007, 13).

more modest than originally anticipated.[45] The decision to invest in China represents, according to the Dunning schema, a classic market-seeking initiative. Having acquired the technology to produce a world-class, market-beating product, Embraer is seeking to capitalize on its initial investment in R&D by maximizing sales. There is no evidence that the decision to invest in China was motivated by a desire to gain access to Chinese technology or know-how.[46]

Embraer's second overseas venture, the acquisition of Portugal's OGMA, also provides evidence of its outward FDI having a market-seeking orientation. OGMA was established by the Portuguese Air Force (FAP) in 1952, specializing initially in the maintenance, repair, and overhaul of the FAP fleet but moving on to limited aircraft production, manufacturing the Auster trainer.[47] In 1994, the same year that Embraer was privatized, OGMA was incorporated, with its shares being transferred to the Ministry of Defense. From 1993 onward, OGMA became an approved maintenance center for the Rolls-Royce AE2100 and AE3007 engines used in the ERJ-145 jet family. However, financial problems generated by managerial mistakes led to worsening financial performance. This contributed to the decision to privatize in 2003.[48] Of the various bidders in the privatization contest, a joint consortium of Embraer and EADS finally proved successful at the end of 2004.

Two key factors may explain Embraer's decision to acquire the assets of what had been a troubled company. First, OGMA acts as an important service facility for Embraer aircraft in Europe and, as such, its acquisition would enhance Embraer's position to build its position in a key external market. Not only would aircraft sales be supported by such a move, but also access would be gained to a fresh revenue stream: maintenance and overhaul. Second, OGMA acts as a subcontractor to the European military aerospace sector. The acquisition of OGMA and the joint-ownership agreement with EADS potentially offers Embraer

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[45] Ibid., 14.
[46] Quite the contrary; the joint venture agreement provides for technology transfer to the local partners rather than the other way around.
[47] Ibid., 16.
[48] Ibid., 17.

enhanced access to the global market for military aircraft.[49] In this connection, Embraer may also be able to benefit from two-way technology transfers as it both transfers its (primarily civilian-based) know-how and receives potentially valuable technological insights from a key military subcontractor. However, the acquisition of OGMA is still a recent event, and the eventual precise nature of technology transfer processes remains to be seen.

Reviewing the Embraer experience, it becomes clear that internationalization (both in terms of exports and outward FDI) has been conditioned by an ability to master demanding technologies and to incorporate them into commercially attractive products. This mastery could not have been achieved without significant state intervention, whether in terms of the establishment of Embraer as an SOE, the development of a supporting network of R&D institutions, or the provision of export finance. By the same token, Embraer would not have been able to thrive without its ability to forge effective alliances with foreign subcontractors. Indeed, it is possible to argue that it is Embraer's facility as a global systems integrator that lies at the heart of its success. The emergence of Brazilian outward FDI projects in China and Portugal represents, for the most part, an attempt to enhance market access rather to engage in the acquisition of new technologies. It will be interesting to observe whether, in any future outward FDI, there is any change in this underlying motivation.

PETROBRÁS

The experience of Petrobrás bears some remarkable similarities to that of Embraer. As in the case of Embraer, Petrobrás originated as an SOE.[50] Like its aerospace counterpart, Petrobrás is a leading exporter and has managed to achieve widespread international recognition for its technological excellence. Operating in a technologically demanding and complex field, Petrobrás also benefited from strong links with Brazil's burgeoning network of research institutes. Like Embraer, Petrobrás has used technological competence as a springboard to internationalization through the pursuit of outward FDI.

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[49] The quest toward enhanced access to the military market intensified further in 2004, when Embraer began to make investments in a Florida ex-military base with the eventual intention of establishing aircraft assembly operations (ECLAC 2005, 73). Presuming such an operation ever commences, it would place Embraer in an advantageous position to gain U.S. military contracts.

[50] Though, of course, Petrobrás remains one.

Petrobrás was founded in 1953 and formed a lynchpin of the state-driven, inward-oriented industrialization drive of the time. As in the case of its Mexican and Venezuelan counterparts, PEMEX and PDVSA, the setting up of Petrobrás as an SOE could be seen as a way of increasing domestic control over national resources. Under the terms of legislation introduced at the time, Petrobrás was granted sole rights over domestic upstream oil production and exploration.[51] It also came to dominate domestic refining activity, although the major foreign oil firms were allowed to retain a role in the downstream distribution sector. For the first two decades of its existence, Petrobrás remained a determinedly domestic player, though it was obliged to gain international experience through its large-scale oil-importation activities. By the early 1970s, change was afoot, however. Substantial rises in the oil price, combined with a desire to guarantee access to foreign oil, led to the establishment of Braspetro.[52] This enterprise sought and obtained foreign exploration and production rights and, famously, discovered the Majnoon field in Iraq in 1975. Braspetro was also heavily involved in establishing oil fields in Libya.

Highly competent though Braspetro's exploration capabilities may have been, by the late 1980s Petrobrás had scaled back its overseas investments. This was in large part due to the need to focus its resources domestically, thanks to the discovery of enormous oil deposits in the Campos Basin, off the coast of Rio de Janeiro State.[53] The physical challenges which were posed by the need to develop this new offshore field were considerable. The geology of the basin was not straightforward, and the water depths involved—at up to 2 kilometers—were far greater than those encountered in the other great offshore fields of the Gulf of Mexico and the North Sea. With no adequate off-the-shelf solutions available, Petrobrás was obliged to develop its own technologies. Thus, in 1986 the enterprise launched the PROCAP (Deep Water Exploration Systems) program. This ambitious program sought to develop the technological capabilities required to design oil platforms and structures suitable for deep waters.[54]

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[51] Unfortunately for Petrobrás, large-scale domestic oil production was not to become a reality until well into the 1980s, by which time market liberalization in this area was close at hand.
[52] Antonio and Lara (2005, 12).
[53] Ibid.
[54] Leite (2005, 81).

As in the case of Embraer, the development of these cutting-edge technologies took place not in a corporate vacuum but within a supportive institutional context. Among the most important elements here was the signing of a partnership agreement in 1987 with the COPPE institute based at the Federal University of Rio de Janeiro. Agreements were also later signed with the IPT at the University of São Paulo (mentioned in the previous section) and the State University of Campinas (Unicamp).[55] University departments involved in the project were also supported by funding provided by FINEP. As well as drawing on outside expertise, Petrobrás has been able to draw on its own—not inconsiderable—in-house resources. These are centered in a special research department named CENPES, which was established in 1963 and now employs some 500 people on a site shared with the Federal University of Rio de Janeiro.[56] To a lesser extent than Embraer, Petrobrás has also collaborated with foreign suppliers, notably with the Scottish firm Weir Pumps.

The pursuit of the PROCAP program has resulted in a torrent of groundbreaking deep water exploration and production technologies including special deep water drills, pumps and semisubmersible platforms. As a result, Petrobrás has been able to operate successfully in ever-deeper waters. Whereas in 1988, two years following the initiation of PROCAP, Brazil's deepest platform operated in 492 m of water, by 2003 the RO 21 platform was operating in water 1,886 m deep. Petrobrás has set a number of world records, including, at one point, the record for the world's deepest exploration well (2,853 m in the Roncador field).[57] Petrobrás has not, of course, neglected more traditional onshore technologies, and it remains a respected exponent in this field.[58]

Perhaps not surprisingly, the development of these impressive capabilities has (literally and figuratively) provided a platform from which Petrobrás has been able to engage in an aggressive program of outward FDI. According to the World Bank's *Global Economic Prospects 2008*, Petrobrás "has used its advanced technology to perform exploration and production work in Angola, Argentina, Bolivia, Colombia, Nigeria, Trinidad and Tobago, and the United

[55] Ibid., 97.
[56] Ibid., 67–68.
[57] World Bank (2008, 62).
[58] Leite (2005).

States and has acquired offshore exploration blocks and interests in Equatorial Guinea, Libya, Senegal and Turkey (Black Sea). It has also recently signed various agreements in China, India, Mexico, Mozambique and Tanzania" (p. 62).

The trigger for this renewed wave of internationalization is twofold. First, of course, the development of pioneering technology has given Petrobrás an edge on its rivals when it has come to mounting credible bids to gain exploration and production rights in new overseas locations. This edge has become even more telling given current oil prices and the fact that all the easily accessible fields have been claimed. In this sense, Petrobrás has found itself with an especially useful technological lever for engaging in Dunning-esque resource-seeking investment.

Second, in what amounts to a push rather than pull factor, Petrobrás has found itself challenged in the domestic market by the emergence of competition in the exploration and production sector. Since 1997, changes in Brazilian law have deprived Petrobrás of its statutory monopoly in these upstream activities, with the result that foreign oil majors such as ExxonMobil and Shell are now operating in the offshore sector. Given this reduced scope for deploying its core competencies at home, it is not surprising that Petrobrás has ventured further overseas.[59]

ODEBRECHT

Odebrecht, which was founded during World War II in the Northeastern state Bahia, is one of Brazil's longest established and most prominent construction companies. According to the U.S. magazine *Engineering News Record*, in 2002 Odebrecht ranked in 29th place among global construction groups according to the scale of its international contracts and 1st among enterprises specializing in hydroelectric projects.[60] Although best known internationally for its work in this field, Odebrecht is in fact quite a diversified group, being also involved in infrastructure and public services, chemicals and petrochemicals, pulp

[59] Antonio and Lara (2005, 12).
[60] Mazzola and Oliveira (2005, 10).

manufacturing, and oil and gas engineering and technical services.[61] Unlike Petrobrás and Embraer, Odebrecht was never an SOE; it was originally established as a family business. However, the state was still to play a crucial role in the evolution of Odebrecht and its accumulation of technological capabilities.

The critical growth period for Odebrecht came during the ISI era, the most dynamic phase of which lasted from the 1950s into the early 1970s. During this period, the state embarked on an unprecedented program of infrastructural investment, with a strong emphasis on highway construction, power generation, and heavy process industries such as steel and petrochemicals.[62] Odebrecht proved highly successful in winning contracts associated with these projects, and it soon moved from being a regional contractor to a full-fledged national player.

It is unlikely that Odebrecht would have achieved the success it did without possessing some core competency unmatched by its less successful rivals. In this regard, there is no doubt that it had a technological and organizational edge thanks to one of the central legacies of its founder, Norberto. This was what Odebrecht terms its Tecnologia Empresarial Odebrecht (TEO, translated loosely as Odebrecht Managerial Technology). The TEO provides a flexible internal organizational structure which devolves as much autonomy—and entrepreneurial decision making—as possible to each manager.[63] Traditional hierarchical structures are eschewed, while the accumulation and transfer of technological knowledge is accomplished through specialized communities of practice within each area of operation.

By successfully winning domestic contracts in infrastructure and heavy industry while deploying this organization model, Odebrecht accumulated considerable technical, planning, and project management skills. While it can be argued that Odebrecht did not enjoy the same close relationship with the state research institutes and universities as, say, Petrobrás,

[61] Oliveira (2007).
[62] Baer (2008).
[63] Mazzola and Oliveira (2005); Oliveira (2007).

working hand in hand with such technologically accomplished SOE clients allowed ample opportunity for knowledge transfer and learning by doing.[64]

Having accumulated the necessary expertise and experience, it is not surprising that Odebrecht began to embark on a program of internationalization. Such a program would, *pace* Hymer and Dunning, allow Odebrecht to leverage its core competencies, generating additional returns. In addition, it can be argued that reductions in Brazilian public sector investment from the late 1970s on may have encouraged Odebrecht to look abroad for business opportunities. Thus, perhaps it is significant that it was in 1979 that it commenced international operations with the construction of the Charcani V hydroelectric dam in Peru.[65] This was followed by the launch of further operations throughout Latin America. International expansion continued rapidly, with a subsidiary launched in Angola in 1984, entry into the European market in 1988, and, in 1991, the start of operations in the United States. Odebrecht's international operations have recently become more diversified and are no longer simply focused on power generation projects. It is now working on rail transportation, airport expansion, water distribution, and highway contracts in countries ranging from Angola to Libya to the United States.[66] This indicates that the enterprise has been diversifying both its expertise and its geographical reach.

OTHER EXPERIENCES

While a lack of space precludes the discussion of some of Brazil's other leading multinationals in detail, it is nonetheless worthwhile making some brief comments about the experiences of Gerdau, Marcopolo, and Vale (CVRD). In the cases of all three, there is evidence that the development accumulation and development of technology has played some role in their process of internationalization. For Gerdau, one of Brazil's longest-established steel producers, its overseas investment, especially into North America, has been strongly driven by a desire to gain market access and to circumvent trade barriers.[67] However, the enterprise has distinguished itself throughout its entirely private sector history

[64] Leite (2005).
[65] Mazzola and Oliveira (2005, 11).
[66] See the Odebrecht Web site, www.odebrecht.com.
[67] Amann et al. (2003). Gerdau's North American investment strategy has been strongly driven by acquisitions rather than greenfield projects.

through its ability to consistently raise productivity and introduce new technology in the enterprises it has acquired.[68] This has obviously assisted its successful drive to internationalize.[69] Still, the case of Gerdau provides little evidence of a close association with state-linked research institutes or innovation programs. This may in part be due to the fact that Gerdau was never in the public sector and the fact that many of the core technologies involved are embodied in the capital equipment provided by outside suppliers.[70]

In the case of Marcopolo, a leading player in the international bus and coach market, a senior manager in a 2005 presentation[71] made it clear that the possession of proprietary technology[72] was a key factor facilitating its internationalization. The desire to capitalize on its technology, plus the need to enter markets using knocked-down kits,[73] has seen Marcopolo establishing assembly facilities across Latin America and also in Portugal and South Africa.[74] Another factor helping to explain Marcopolo's internationalization drive has to do with the desire to reduce transportation costs; it has proved more cost-effective to ship components rather than finished vehicles to some locations.[75]

The desire to exploit homegrown expertise on an international scale also characterizes the internationalization of a much larger Brazilian enterprise: the mining giant Vale. Like Embraer, Vale is a former SOE[76] with strong roots in Brazil's ISI era. In common with Petrobrás, Vale was established with the aim of enhancing national control over domestic natural resources. While still an SOE, CVRD entered an initial phase of internationalization through minerals exports (especially iron ore). Following its privatization in 1997, Vale embarked on an aggressive path of internationalization through acquisitions and the signing of joint ventures with foreign enterprises. This has involved two paths—one emphasizing

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[68] Alem and Cavalcanti (2005, 65).
[69] Ibid.
[70] For a detailed study of the technological trajectory of the steel equipment sector in Brazil, see Amann (2000).
[71] Martins (2005).
[72] The technology involves centers on windows, bus interiors, coach building and, like Embraer, systems integration.
[73] Shipping in such kits for local assembly often means that high duties on imported assembled vehicles are avoided.
[74] Alem and Cavalcanti (2005, 67).
[75] ECLAC (2005, 74).
[76] Vale is the new name for an enterprise which, until recently was called CVRD (Companhia Vale do Rio Doce).

the mineral processing part of the production chain and the other the mineral exploration component.[77] Perhaps significantly, Vale has been rather more active in the field of exploration activities,[78] an area in which it has been able to deploy its technological capacities to facilitate a successful resource-seeking strategy.[79] The Vale case demonstrates, once again, how competencies established in the domestic sphere under an inward-oriented industrialization strategy can later be deployed to good effect internationally.

VI. CONCLUSION

The growing prominence of homegrown multinational corporations has been one of the most striking features of the recent resurgence of the Brazilian economy. This article has demonstrated that outward FDI by Brazilian enterprises is being strongly driven by a desire to access markets and natural resources. However, as the theoretical work of Dunning and others demonstrates, such internationalization requires as a precondition the possession of some key competence or advantage. It has been suggested that the development of specific technological capabilities could constitute such an advantage.

From the evidence reviewed, it is clear that certain Brazilian enterprises have developed such capabilities and are now seeking to capitalize on them through accelerated outward FDI. The emergence of these capabilities has been—in many instances—strongly conditioned by the actions of the state. Whether through public ownership (in the case of SOEs), the establishment of R&D institutes, or the initial pursuit of ISI, the state provided an environment in which certain enterprises could build technological competence. Still, as section III demonstrated, public spending on technology is now under significant pressure. This must call into question the ability of the state to continue supporting innovation in the productive sector. Significantly, all the multinationals reviewed "got their technological start" in the ISI period, when the state's financial capacity in this area was stronger than it is today.

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[77] Spanazzi de Oliveira and Mendes de Paula (2005, 10–11).
[78] Ibid.
[79] Ibid., 18–20.

It will be interesting to see whether a future generation of Brazilian multinationals emerges from the current policy context.

Does the emergence of Brazil's successful multinational corporations from an earlier epoch of state-driven development mean that it is now time to reappraise the latter period in a more favorable light? Can it really be said that all those years of accelerated public investment under ISI have finally paid off? These are perhaps two of the most profound—and difficult-to-answer—policy questions to spring from the discussion. While it is difficult to envisage the emergence of Brazil's current crop of homegrown multinationals without the pursuit of state-driven, inward-oriented industrialization, by the same token it is important to recognize the broader efficiency costs and distortions that came as part of the package. These eventually became unsupportable and, arguably, stifled the growth of enterprises without privileged access to state finance or contracts. The end of ISI and Brazil's tortuous exit from it also brought painful adjustment costs. These, too, need to be factored in when appraising the years of intensified state intervention. Still, there is no doubt that, through its legacy of world-class multinationals, the ISI period, in one respect at least, is now paying significant dividends.

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